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ABSTRACT

This study of the role which learner control plays in the success of interactive courseware (ICW) was designed to determine whether providing students with an option to review content in ICW--when attempting to answer embedded questions--improves their achievement on a posttest without adversely affecting the amount of time it takes to complete the instruction. The subjects were 58 Army ROTC cadets and 12 students from the undergraduate teacher program at the University of Kansas, who were randomly assigned to groups. The groups were then randomly assigned to treatments. The independent variable was analyzed for effect in relation to five dependent variables: (1) achievement in relation to fact questions, procedure questions, problem solving questions, and total score; (2) instructional time; (3) attention time; (4) review time; and (5) acquisition rate. The independent variable was learner control of a Content Review Option (CRO). An eight-lesson course on military map reading was converted into two versions of computer assisted instruction (CAI). In version 1, subjects had access to a summarized review of a lesson's content after the lesson had been completed but before encountering the embedded questions. In version 2, subjects had access to the review at the end of a lesson, when a question was presented, and after receiving feedback to a question response. The recall posttest was a 21-item multiple choice test. Subjects were also asked to respond to seven questions after taking the posttest. Analyses of the data indicated that providing a content review option did not produce a significant difference between the groups on any of the variables. A discussion of the results and seven recommendations conclude this paper. (48 references) (BBM)

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# Title:

# Learner Control of Review in Computer Assisted Instruction within a Military Training Environment

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IR014536

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## Learner Control of Review in Computer Assisted Instruction within a Military Training Environment

In 1988 the United States Army planned on spending in excess of 1.2 billion dollars on individual training, and in 1989 that budget increased to 1.3 billion dollars (Office of the Director of the Army, 1987). Although these dollars represent only a small fraction of the total Army budget, they indicate that the Army's commitment to training is extensive. In the face of Congressional pressure to limit the Defense Budget as part of a general plan to bring the National Debt under control, the US Army must make every effort to increase training efficiency and effectiveness. A major source for achieving better quality training has been the use of instructional technology which Gagne´ (1987) defines as practical techniques of instructional delivery that systematically aim for effective learning.

The issue of efficiency in the training environment has a long tradition in the Army. Many of the developments in instructional technology used in the educational environment at large came from research conducted for the military since World War I (Noble, 1988). The use of computers as a medium of instructional technology has been a major contribution to the developmental progression of this technology. Most recently the Army has commenced an effort to integrate the use of personal computers to deliver instruction at various training institutions. Invariably the success of the Electronic Information Delivery System (EIDS) will rest on the quality of the instructional software, officially referred to as Interactive Courseware (ICW) (TRADOC, 1987).

One method of making a qualitative change in ICW is improving the nature of interactivity between the student and the computer. A feature of interactivity that can be manipulated by the instructional designer is the amount of learner-control afforded by the courseware. Over the years the term, learner-control, has meant different things to instructional designers. The first educational use of the term learner-control (Mager & Clark, 1963) referred to the student's ability to sequence the content of a particular course of instruction. Later, allowing the student the ability to control the pace of instruction came under the heading of learner control. Research has also been done that allow the learner to control the questions and style of instruction (McCann, 1981). Because the term learner control can be used in reference to different features of ICW, a descriptor is used to qualify type (e.g. learner-control of review).

The role which learner control plays in the success of ICW is not entirely clear. Several studies have suggested that learner control can be as simple as control of pace and be very successful in terms of achievement (Park & Tennyson, 1983; Ross & Rakow, 1981 among others). A meta-analysis by Steinberg (1977) indicates that external control of instruction by the computer is as effective as learner control and has the added advantage of taking less time to complete, which has implications for the efficiency of instruction. Other studies have suggested that giving the learner more control over the instruction has produced positive results (Merrill, 1980; Hannafin & Colamaio, 1987). One advantage for learner control that seems to be consistent is that students show a better attitude toward the instruction when they have greater control, which in turn increases motivation (Sawyer, 1985). Because of these inconsistencies, Snow (1980) has put forth the argument that the conditions of effective learner control still merit study. The result is that a primary emphasis of CAI design research has been on learner control of pace and content sequence, but there has been little significant research on

providing the learner with the ability (control) to review content when the student feels a need for review.

The present research was prompted, in part, by design constraints noted in two related research projects (Ho *et al.*, 1986; Kinzie *et al.*, 1987). In the study conducted by Ho *et al.* (1986) the ICW did not include embedded questions as a part of the instructional design. One explanation for the significance the review option that study achieved, was possibly due to the absence of review questions. The Kinzie *et al.* (1987) study compared program and learner controlled review of embedded questions after an incorrect response. The study achieved significance which favored the use of learner control. Yet, that research leaves open the question of whether a review is better than not having a review. The present study addressed both issues.

The theoretical base for the research questions addressed came from a review of past CAI research, research based ICW design factors, map reading, and military training. More recently several studies have examined different design factors including; embedded questions, feedback, learner control, screen design, and the use of text. The design component investigated in the present project was the use of review; which are those activities that make use of the content after the original learning has occurred (Blair *et al.*, 1968). The research used to support the hypotheses came from a synthesis of findings found in research concerning traditional teaching techniques, open-book testing, and use of review in ICW. The conclusion was that there is sufficient evidence to suggest that a review option could improve a students achievement on fact, procedure, and problem solving questions without adversely effecting efficiency.

The central research question was: "Does providing students with an option to review content in ICW, when attempting to answer embedded questions, improve their achievement on a posttest without adversely effecting the amount of time it takes to complete the instruction?" The courseware made use of fact, procedure, and problem solving questions, which represents three different types of learning (Schaffer &Hannafin, 1986).

Independent and Dependent Variables

The independent variable for this study was analyzed for effect in relation to five dependent variables. The independent variable was learner control of a Content Review Option (CRO). A course on military map reading, that contained eight lessons, was converted, using research based design principles, into two versions of CAI from an existing programmed text. In version one, Limited Access to the Content Review Option (LACRO) (Fig. 1), subjects had access to a summarized review of a lesson's content after the lesson had been completed but before encountering the embedded questions. In version two, Open Access to the Content Review Option (OACRO) (Fig. 2), subjects had access to the review at the end of a lesson, when presented a question, and after receiving feedback to a question response. The five dependent variables were achievement [four factors: 1) fact questions; 2) procedure questions; 3) problem solving questions, and 4) total score], instructional time, attention time, review time, and acquisition rate.

Instrument

The recall posttest was a 21 item, multiple choice test. The test covered seven lessons found in the ICW. Each sub-lesson had a fact, procedural, and

problem solving type question. The test was patterned after a test designed by the U.S. Army. The test was reviewed by a panel of three independent subject matter experts (inter-rater reliability = .95), and went through post-hoc reliability testing ($\alpha = .68$). The following criteria were used for the design of each question (Hannafin & Colamaio, 1987):

Factual - Requires the literal, verbatim recall of information presented during the lesson.

Procedural - Requires the integration and transfer of the lesson's factual information to a series of related tasks.

Problem Solving - Requires the application of facts or procedures to the solution of novel problems.

In addition to the posttest, an informal post-treatment questionnaire was completed by each subject. The questionnaire had seven questions relating to the subjects use of the CAI and review option. The results from this survey are covered later.

Subjects

The subjects used in this study were 58 Army ROTC cadets drawn from the MS I (freshman), MS II (sophomore), and MS III (junior) classes at the University of Kansas. An additional 12 subjects were drawn from the undergraduate teacher program in the School of Education. The subjects were randomly assigned to groups and the groups were randomly assigned to treatments.

Data Treatment

A two-group design was used for this research. The dependent variables for achievement, and attention time were analyzed using MANOVA procedures. ANOVA procedures were used to analyze the acquisition rate data. ANOVA procedures were used to analyze the instructional time data, and ANCOVA procedures were used to analyze the effect of review time on instructional time. The level of significance was set at .05.

Results

Hypothesis One: Posttest

The null hypothesis states that there is no significant difference in achievement between the groups as measured by the achievement posttest. The score recorded has a possible range of 1 - 21 and is one of four scores recorded using one posttest. The sub-scores for fact, procedure, and problem solving questions are discussed in hypothesis two.

To test Hypothesis One, a MANOVA was done on the posttest data using the SPSSx statistical package on the University of Kansas VAX computer system. The Hotellings criterion for multivariate analysis yielded, $F(4,65) = .659$, $p = .623$, which was not significant. Mean scores, standard deviations, and sample sizes for the two groups are reported in Table 1. The results of univariate F-Tests are shown in Table 2. Hypothesis one was not rejected.

## Hypothesis Two: Fact, Procedure, and Problem Solving

The null hypothesis has the following three parts. One, there is no significant difference on achievement for fact type questions between the two groups. Two, there is no significant difference on achievement for procedure type questions between the two groups. Three, there is no significant difference on achievement for problem solving type questions between the two groups. The MANOVA returned, $F(4,65) = .659$, $p=.623$, which was not significant. Descriptive statistics are presented in Table 3, and inferential statistics are included in Table 4. Hypothesis Two was not rejected.

## Hypothesis Three: Acquisition Rate

The null hypothesis states that there is no significant difference in acquisition rate between the two groups. Acquisition rate was based on the recall to instructional time ratio (total points on posttest divided by instructional time in minutes and seconds). Acquisition rate was a time-based indicator of learning efficiency for the two treatments (Schaffer & Hannafin, 1986). A one-way ANOVA, using the MYSTAT (SYSTAT, Inc.) computer package on a Macintosh SE, was done on the acquisition rate data. The computed ANOVA for the difference between the treatment groups was, $F(1, 68) = 3.455$, $p=.067$. Therefore, hypothesis three was not rejected. Means, standard deviations, and number of cases are displayed for each group in Table 5. The ANOVA summary is presented in Table 6.

## Hypothesis Four: Attention Time

The null hypothesis stated there is no significant difference in attention time between the two groups. The data is divided into nine parts. The first eight parts was the time spent on each lesson. The ninth data point was the cumulation of parts 1 through 8. MANOVA used to analyze these data yielded the following, $F(9,60) = 1.139$, $p=.351$, which was not significant. Hypothesis four was not rejected. Means, standard deviations, and cell sizes are shown in Table 7. Relevant univariate F-tests are included in Table 8.

## Hypothesis Five: Instructional Time

The fifth hypothesis states that there is no significant difference in instructional time means between the two groups. Instructional time was the amount of time it takes a learner to complete the entire course of instruction. Measurement commenced when the first instructional screen was encountered and terminated when the last screen of the lesson was completed. An ANOVA was performed which produced a significant instructional time effect, $F(1, 68) = 4.309$, $p=.042$. Therefore Hypothesis Five was rejected. To further test the probability that the review option was the cause for the significant difference in Hypothesis Five an ANCOVA, using the MYSTAT statistical package on a Macintosh SE computer, was done using the review time data as the covariate. The computations resulted in, $F(1, 67) = .770$, $p=.383$, which was not significant. Means, standard deviations, and cell size are reported in Table 9. ANOVA, and ANCOVA summaries are shown in Tables 10 and 11 respectively. The interpretation is that the OACRO group spent significantly more time using the map reading CAI and that this increase in time was because of review time.

Informal Data

After the subjects took the posttest they were asked to respond to seven questions. The responses to those questions are described in the following paragraphs.

Question 1; "Were you aware of having the option to review the course material?" Responses indicate that 95.7% of all the subjects knew they had the option to review the material.

Question 2; "Did you know when you could use the review option?" A majority of respondents (97%), that answered positively in Question 1, replied positively to question 2. The high percentage of positive responses to these two questions led to the conclusion that retention of the null hypotheses was not because of subject ignorance of the content review option.

Question 3; "Do you think you would use the review more often if you could see the questions before deciding if you wanted to review?" This question was only directed to those subjects in the group that had limited access to the review. The majority of subjects (81.3%) responded "Yes" to this question. This response compares favorably with the behavior of the subjects in the open access group since 91% used the review after they saw the questions.

Question 4; "What type of question did you use the review on most often?" This question was directed to the subjects in the group that had open access to the review. The tally indicates that; 8.6% did not use the review when the question was presented, 17.1% used the review only on fact type questions, 2.9% used the review only for procedure type questions, 11.4% used the review only for problem solving questions, 57.1% used the review on both fact and procedure type questions, and 2.9% used the review for all the types of questions. In general, students accessed the review most often for questions which require the use of rote memory.

Question 5; "Do you think you would use the review more often if the questions were fill-in-the-blank, or short answer?" As with Question 4 this question was directed at only the subjects in the open access group. The majority (74.3%) of the OACRO subjects responded positively to this question. This response rate suggests that the use of multiple-choice questions effected a subject's decision to use the review option.

Question 6; "What changes in training conditions do you believe would cause you to use the review more often?" Two conditions emerged. A minority (21%) of all the subjects indicated that if they were required to spend a specified amount of time in the training session - which exceeded the amount of time it would normally take to complete the instruction - they would use the review. A majority (61%) of all the subjects indicated that if a minimum standard of achievement was established for passing then they would probably use the review more often. This indicates that the conditions under which the research was conducted influenced a subject's decision to use the review. The other 18% of the subjects gave no answer to this question.

Question 7; "Did you have any problems using the courseware on the computer?" A majority (93%) of all the subjects indicated that they had no

difficulty using the CAI medium employed in the present research. The researcher concludes that the user interface of the instructional medium did not adversely effect achievement.

Conclusions

Regarding achievement, it was concluded that providing a content review option did not produce a significant difference between the groups. This was also true for the three types of questions used to make up the posttest. This indicates that the effect the use of review questions had on student achievement was not enhanced when a content review option is added to the instructional design. Since the content in this study is comparable to the content used in the studies conducted by Ho *et al.* (1986) and Kinzie *et al.* (1987) the present research raises questions regarding generalizations made in those previously mentioned studies. The Ho *et al.* (1986) study declared that the results indicate the use of review, in the form of a lesson summary, is an effective instructional design strategy. Since that study did not use embedded questions, which is considered a ICW design imperative (Alessi & Trollip, 1985; Wager & Wager, 1985; Hannafin & Peck, 1988), then it is reasonable to question if the same results would be realized if embedded questions were used in conjunction with the review option. Kinzie *et al.* (1987) recognized that research conducted in this area should be done within the context of sound instructional design. The review option designed for that study complimented the use of embedded questions but, the review could only be accessed after an incorrect answer, which may be a design limitation rather than a design flaw. On the basis of their results they stated that learner control of review was a practical design factor. Kinzie *et al.* (1987), however, did not address whether or not review plus embedded questions is more effective than embedded questions alone.

A comparison of the results of these two research efforts suggests that installing a content review option in addition to the use of embedded questions would be an effective ICW design. But the results of the present study indicates the positive effects noted in the Ho and Kinzie studies are not additive. The effects of review may be absorbed by the effect that the use of embedded questions has on student achievement regardless of the type of question used.

The results of the present study also contradict the findings regarding students attention to content found in the literature on open book testing. The research reviewed (Kalish, 1958; Krarup *et al.*, 1974; Weber *et al.*, 1983; Boniface, 1985) consistently found that students facing an open book testing situation spent less time studying the content to be tested than students in a closed book testing situation. In this study there was no significant difference between the attention time for the LACRO ($\underline{M}$ = 47.49 min.) and the OACRO ($\underline{M}$ = 54.96 min.) groups. One possible explanation is that when students use CAI, they become absorbed by the methodical process of going through the instruction. Also, students are usually in an environment conducive to study (i.e., computer lab, or learning center) whereas, studying text allows the student to quickly skim material or not read the content. Unless students make a conscious effort to put themselves in an environment conducive for study the potential for innumerable distractions (i.e. TV, radio, other people) exists.

Acquisition rate was not significant. This fact supports the conclusions drawn from the data on the posttest. The review option does not increase or decrease a student's ability to learn from the CAI. Since the review option does not

hinder or help acquisition the designer must draw on other information to make a design choice.

These conclusions do little to address the highly vocal critics of CAI that regularly cite the linear function of many ICW programs as being limited or too simplistic to address the needs of learners (Bork, 1982; Pogrow, 1988; Streibel, 1986). Instead of concluding that the present study has failed to meet the demands of the critics, I would suggest that the critics are overstating their case. It may be that learners do not employ their entire repertoire of cognitive skills in every learning situation. The result is that for certain content or learning situations a linear approach may be the optimum way to communicate the instruction to the student; other studies suggest that such is the case (Hilgard, Atkinson & Atkinson, 1975).

Limitations

A partial explanation for the lack of significance in the results of this research can be explained by noted limitations. Six areas have been identified as potentially effecting the results of this study. These items include; length of the instruction, subject motivation, embedded and posttest question style, type of problem solving, learner characteristics, and student use of learner control.

The instruction used in the present study was much longer than the instruction used in similar studies. Subjects spent an average of 78 minutes in just the CAI portion of the treatment. This exceeds normally accepted standards for the amount of time, about 50 minutes, an adult learner is expected to maintain attention on content without a break. As a result, subjects demonstrated signs of fatigue (i.e., poor posture, yawning) during the experiment which could have had an adverse effect on learning. This effect however, should have been consistent across the treatments since the amount of instruction was the same for both groups.

Since there were no external incentives used in the experiment, motivation to master the content was determined by the subject's internal desire to learn map reading. This may have adversely effected learning, or the use of review, as indicated in the following posttest question: "What changes in training conditions do you believe would cause you to use the review more often?". The result was that 61% (43/70 S's) of the subjects indicated that establishing a required minimum score would have caused them to use the content review option more often, with another 21% (15/70 S's) indicating that a required period of time (that exceeds the actual amount of time to complete the instruction) for studying the instruction would cause more extensive use of the CRO. Therefore, it seems reasonable to assume that motivation had an effect on the use of review, which may have ultimately had an effect on achievement.

The use of multiple choice questions was also a limiting factor which may have adversely effected the use of review. Multiple choice questions do not require pure recall by the subject since the possible answers provide cues that aid recall. Also, the subjects admitted to a willingness to guess at the correct answer, before using the review, since there was no penalty for an incorrect response to a question. Most of the subjects in the OACRO group (74%, 26/35 S's) indicated on the post-treatment questionnaire that the use of fill-in-the-blank, or short answer questions would probably have caused them to use the review more often.

Another limiting factor that may have affected the use of review was the type of problem solving presented in the ICW. Specifically, problem solving was

limited to algorithms. This type of problem solving is a given procedure that will result in a successful solution when it is consistently followed (Ingram, 1988). Doing an intersection on a map is an example of algorithmic problem solving. Algorithmic problem solving is on the low end of a continuum with heuristics representing the opposite end. A heuristic is a general strategy that can be used to approach a problem in such a way that it will not ensure success but will increase the probability of arriving at an acceptable solution. By their very nature heuristics are difficult to teach no matter what the method (Ingram, 1988). This is because they can involve the use of complex constructs and higher order rules with inconsistent applications (i.e., rules of spelling for English).

Because all soldiers, regardless of ability, are expected to be able to use a military map, the algorithms used in the map reading ICW must be clearly explained. Therefore, the algorithms involved were limited in complexity and applied in precisely defined situations. This made the problems in the map reading ICW comparatively easy to understand and solve given the quality of the instruction along with the high ability level of the subjects. The result is that the review was merely a tool to aid recall instead of being used to clarify concepts. This is highlighted by 89% (31/35 S's) of the subjects that reported on the post-treatment questionnaire (Question 5) that they primarily used the review to look up answers for the fact and procedure type of questions.

As alluded to above, ability level may have also been a factor. Other studies (Schaffer & Hannafin, 1986; Kinzie, 1987) have found that segregating the sample by measured learner characteristics had an effect on the data collected. Since the subjects were not broken down by ability level for the present research this issue can not be addressed. It is quite possible that by expanding the present research to distinguish subjects that represent the enlisted population in the Army, which have inconsistent educational backgrounds, a significant effect may have been achieved. Therefore, using the same content and design factors an aptitude-treatment interaction may reveal effects that were not found in the present study.

The last limitation falls in the area of student use of learner control. While it was noted in the post-treatment questionnaire that over 95% of the subjects were aware that the option to review the course content there is no indication that the subjects knew how to incorporate the review option into their study habits. Therefore, it must be assumed that the subjects knew how to make the best use of the learner control afforded them in this study. Clark (1982) reviewed a number of studies and has suggested that by mistake students choose methods of study that inadvertently result in less learning. In other words, merely providing someone a tool to do a job is no guarantee that they will know how to properly use the tool. Clark's review taints the aforementioned assumption and renders it tenuous at best.

Recommendations

Lack of significance in four of five stated hypotheses could lead to the conclusion that the use of review does not make a difference in a student's ability to achieve. Further, providing a review option may use the student's time to no apparent advantage. Such assumptions, however, should be tempered by previously mentioned limitations and an understanding that parallel access to information is a recently developed feature available in ICW. As learners become more familiar with learner control mechanisms, then the effects of these mechanisms (under different conditions) may become apparent. With this in mind, the following recommendations are offered:

First, the length of time a student must devote to the CAI, in one sitting, should be limited to generally accepted practices for more traditional forms of instruction (i.e., a 10 minute break every 50 minutes), so that fatigue does not act as an confounding variable. This can easily be accommodated by the computer software so that subjects can continue instruction from where they left off. Considering the effects computer monitors have on the eyes, and considering that text presented on monitors impairs reading efficiency, there is reason to study how these factors affect attention.

Second, the presence of external motivators should be examined as an independent variable with the use of review since the post-treatment questionnaire indicated that subjects would be more inclined to use the review if external motivators (i.e., minimum score) were applied.

Third, further research in this area should avoid the use of multiple choice questions since this type of question does not adequately measure a students ability to recall information, or demonstrate understanding of higher order rule using. If the embedded questions are designed to use more sophisticated question styles then an increase in programming complexity will be needed. Again, the results taken from the post-treatment questionnaire suggests that changing this part of the research would cause an increase in the use of the review. The unanswered question is; "Would an increase in the use of the review cause an increase in student achievement?"

Fourth, since the content of the instruction used for the present research did not seem to break the threshold of effectiveness that a simple, linear ICW design provided; a modification should be made to the research design. An effort should be made to examine the effect a content review option has on a students ability to learn content that either has complex algorithms, or requires the application of heuristic problem solving techniques. It is possible that more complex content would tender results that support the use of a content review option.

Fifth, further research should be conducted taking into account learner characteristics. This proposed research could organize the subjects according to reading ability, verbal learners, non-verbal learners, or spatial ability to name a few. In light of the evidence from previous research that has examined learner characteristics as an independent variable this could prove to be a promising research tack to pursue since the best instructional method for one learner may not necessarily be the best instructional method for another.

Sixth, research should be undertaken that examines the effectiveness of training subjects how to use learner control. As ICW becomes more sophisticated student control will also increase. As a result of this increased control it may become necessary to teach students how to use the ICW to their advantage. Additionally, the development of consistent design features which are used to access and navigate through information may greatly enhance the effectiveness of learner control options. In order to best evaluate the effectiveness of these concepts this research may need to be conducted in a situation where learner characteristics are also controlled.

Last, further research should be conducted that examines the idea that, for different content domains, there may exist different, optimal design structures. If true, then instructional designers would gain a valuable tool to help make decisions

that affect the use of resources needed for constructing ICW. The value of this is emphasized by instructional designers, in industry and the military, propensity to heavily weight efficiency as a design criterion. The present research being an excellent case in point. Considering that the LACRO group spent significantly less time ($\underline{M}$ = 74.02 min.) processing the CAI than the OACRO group ($\underline{M}$ = 83.38 min.) with no discernable difference in achievement then, from an instructional designers perspective, it makes little sense to expend the additional resources required in designing, installing, and evaluating the content review option. Therefore, having the ability to prescribe the combination of design factors that effectively communicate a certain topic to the student, enhances efficiency in the planning and development phases of the instructional design.

When you consider that the goal of professional trainers is to expeditiously and by least cost produce a person with the skills necessary to be able to function in an occupational area and that experience is still considered the best teacher then there is a strong argument for using modest courseware designs for certain topics. Unpretentious courseware design have proven effective in numerous cases and should be recognized for their elegance instead of being chided for not fulfilling the expectations of those that do not, on a day-to-day basis, deal with the complex issues of the training arena.

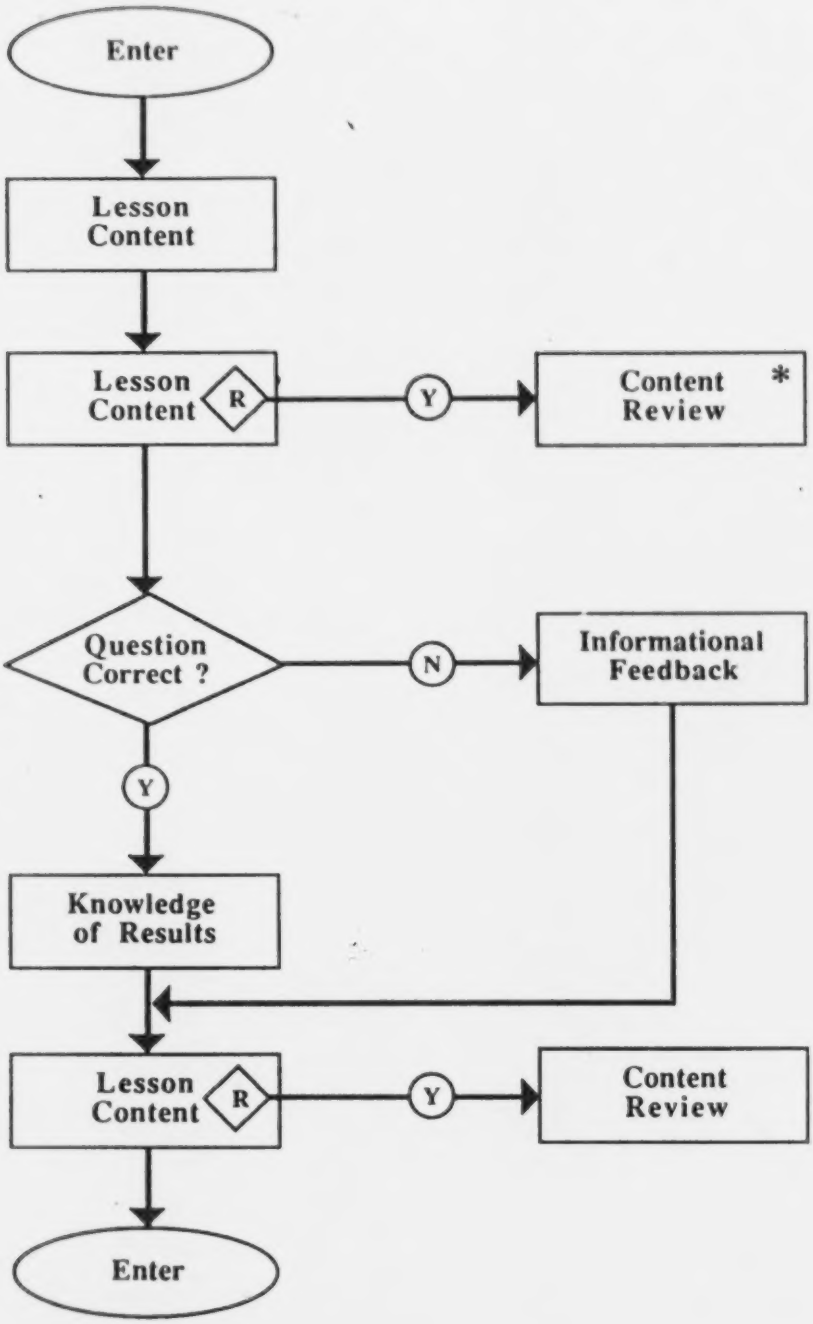


Figure 1

Limited Access to the Content Review Option (LACRO)
(* After review student returns to point-of-access.)

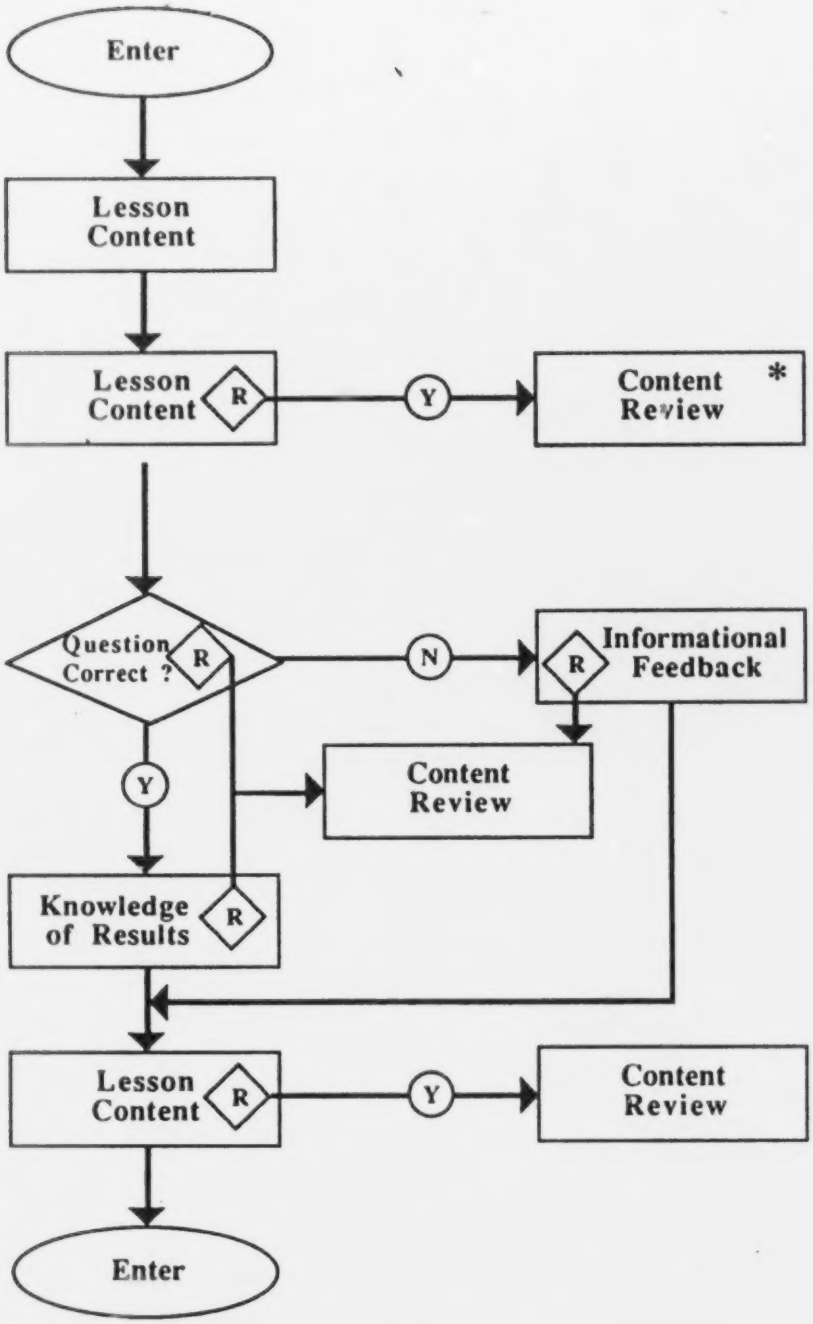


Figure 2

Open Access to the Content Review Option (OACRO)
(* After review student returns to point-of-access.)

Table 1

Means, Standard Deviations, and Group Sizes Obtained for Total Posttest Scores

| Group | n | Means | S.D. |
|---|---|---|---|
| LACRO | 35 | 16.829 | 3.044 |
| OACRO | 35 | 15.914 | 2.832 |

Maximum score = 21.

Table 2

Summary Table of the Univariate Analysis of Variance Using the Posttest Total Score Data

| Source of Variation | DF | Sum of Squares | Mean Squares | F Ratio |
|---|---|---|---|---|
| Group | 1 | 14.629 | 14.629 | 1.693 |
| Within Cells | 68 | 587.714 | 8.643 | |

Table 3

Posttest Means, Standard Deviations, and Group Sizes Obtained for Fact, Procedure, and Problem Solving Achievement Scores

| Question Type | Means | S.D. |
|---|---|---|
| | LACRO (n = 35) | |
| Fact | 5.486 | 1.147 |
| Procedure | 5.971 | 1.043 |
| Prob. Solving | 5.429 | 1.632 |
| | OACRO (n = 35) | |
| Fact | 5.171 | 1.200 |
| Procedure | 5.714 | 1.126 |
| Prob. Solving | 5.229 | 1.505 |

Maximum score for each subscale = 7.

Table 4

Summary Table of the Univariate Analysis of Variance Using the Posttest Fact, Procedure, and Problem Solving Score Data

| Source of Variation | DF | Sum of Squares | Mean Squares | F Ratio |
|---|---|---|---|---|
| | | Fact Question | | |
| Group | 1 | 1.729 | 1.729 | 1.254 |
| Within Cells | 68 | 93.714 | 1.378 | |
| | | Procedure Question | | |
| Group | 1 | 1.157 | 1.157 | .982 |
| Within Cells | 68 | 80.114 | 1.178 | |
| | | Problem Solving Question | | |
| Group | 1 | 2.800 | 2.800 | 1.240 |
| Within Cells | 68 | 153.543 | 2.258 | |

Table 5

Means, Standard Deviations, and Group Sizes Obtained for Acquisition Rate

| Group | n | Means | S.D. |
|---|---|---|---|
| LACRO | 35 | .243 | .085 |
| OACRO | 35 | .206 | .083 |

Table 6

Summary Table of the Analysis of Variance Using the Acquisition Rate Data

| Source of Variation | DF | Sum of Squares | Mean Squares | F Ratio |
|---|---|---|---|---|
| Group | 1 | .025 | .025 | 3.571 |
| Within Cells | 68 | .483 | .007 | |

Table 7

Means and Standard Deviations for LACRO and OACRO Lesson Times

| Group | Means | S.D. |
|---|---|---|
| | LACRO (n = 35) | |
| Lesson 1 | 3.475 | 2.053 |
| Lesson 2 | 9.478 | 4.208 |
| Lesson 3 | 4.995 | 2.199 |
| Lesson 4 | 7.153 | 2.442 |
| Lesson 5 | 8.825 | 2.977 |
| Lesson 6 | 4.230 | 2.689 |
| Lesson 7 | 3.834 | 2.918 |
| Lesson 8 | 5.503 | 4.455 |
| Lesson Total | 47.491 | 18.248 |
| | OACRO (n = 35) | |
| Lesson 1 | 4.276 | 2.105 |
| Lesson 2 | 10.939 | 4.106 |
| Lesson 3 | 5.890 | 2.352 |
| Lesson 4 | 7.543 | 2.619 |
| Lesson 5 | 9.756 | 2.353 |
| Lesson 6 | 5.171 | 2.087 |
| Lesson 7 | 5.003 | 2.935 |
| Lesson 8 | 6.380 | 4.262 |
| Lesson Total | 54.958 | 16.169 |

Table 8

Summary Table of the Univariate Analysis of Variance Using the Lesson Time Data

| Source of Variation | DF | Sum of Squares | Mean Squares | F Ratio |
|---|---|---|---|---|
| Lesson 1 | | | | |
| Group | 1 | 11.246 | 11.246 | 2.601 |
| Within Cells | 68 | 293.972 | 4.323 | |
| Lesson 2 | | | | |
| Group | 1 | 37.369 | 37.369 | 2.163 |
| Within Cells | 68 | 1175.056 | 17.280 | |
| Lesson 3 | | | | |
| Group | 1 | 14.033 | 14.033 | 2.708 |
| Within Cells | 68 | 352.374 | 5.182 | |
| Lesson 4 | | | | |
| Group | 1 | 2.673 | 2.673 | .417 |
| Within Cells | 68 | 435.965 | 6.411 | |

(continued on next page)

Table 8 (cont.)

| | | | | |
|---|---|---|---|---|
| Lesson 5 | | | | |
| Group | 1 | 15.162 | 15.162 | 2.106 |
| Within Cells | 68 | 489.671 | 7.201 | |
| Lesson 6 | | | | |
| Group | 1 | 15.490 | 15.490 | 2.674 |
| Within Cells | 68 | 393.955 | 5.793 | |
| Lesson 7 | | | | |
| Group | 1 | 23.904 | 23.904 | 2.792 |
| Within Cells | 68 | 582.265 | 8.563 | |
| Lesson 8 | | | | |
| Group | 1 | 13.478 | 13.478 | .709 |
| Within Cells | 68 | 1292.599 | 19.009 | |
| Lesson Total | | | | |
| Group | 1 | 975.724 | 975.724 | 3.283 |
| Within Cells | 68 | 20209.796 | 297.203 | |

Table 9

Means, Standard Deviations, and Group Sizes Obtained for Overall Time Using CAI (Course Time)

| Group | n | Means | S.D. |
|---|---|---|---|
| LACRO | 35 | 74.018 | 18.868 |
| OACRO | 35 | 83.375 | 18.850 |

Table 10

Summary Table of the Analysis of Variance Using the Course Time Data

| Source of Variation | DF | Sum of Squares | Mean Squares | F Ratio |
|---|---|---|---|---|
| Group | 1 | 1532.429 | 1532.429 | 4.309 * |
| Within Cells | 68 | 24185.214 | 355.665 | |

* p = .042

Table 11

Summary Table of the Analysis of Covariance of Total Course Time and Review Time Data as the Covariate

| Source of Variation | DF | Sum of Squares | Mean Squares | F Ratio |
|---|---|---|---|---|
| Group | 1 | 275.748 | 275.748 | .770 |
| Review Time | 1 | 183.041 | 183.041 | .511 |
| Within Cells | 67 | 24002.172 | 358.241 | |

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